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Cloud Computing Adoption by firms

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CLOUD COMPUTING ADOPTION BY FIRMS

Abstract

In recent years Cloud Computing has been one of the most discussed references in the world of information technology. As the adoption of Cloud Computing has become so important for firms, a question arises: what are factors determining the adoption of technology? Thus, the aim of this study is to identify a set of determinants of adoption of Cloud Computing by firms. To reach this goal we suggested a research model based on two theories held in the literature: the diffusion of innovation (DOI) model and the technology organization environment (TOE) framework. To support the suggested model a list of measure items is even proposed to test the suggested propositions. The implications of the results of this study are discussed, both for researchers and for managers. We present the plan to the empirical testing and model validation of the propositions suggested. Future extensions to this study are also considered in this paper.

Key words: Cloud Computing; IT adoption; Technology Organization and Environmental (TOE) framework; Diffusion of Innovations (DOI).

1 INTRODUCTION

In recent years, the term *Cloud Computing* has been crucial in the world of information technologies (Low et al., 2011, Sultan, 2010, Ortiz, 2011, Buyya et al., 2009), so that it has emerged as one of the most discussed references. Buyya et al. (2009) even claim that *Cloud Computing* has the potential to transform a large part of the information technology (IT) industry, making software even more attractive as a service. Despite the intense discussion of the characteristics of *Cloud Computing* technology, in the knowledge which has been possible to reach, there are few studies on the reason for adopting this technology. This research aims to fill this gap by analysing a set of determinants in the adoption of *Cloud Computing* by firms. But, the adoption of *Cloud Computing* having become so important for firms, one question arises: what are factors determining the adoption of *Cloud Computing*. It is thus of particular importance to understand the process of adoption. In this paper, we develop a research model of the adoption of *Cloud Computing* by firms based on two models already signed: the diffusion of innovations (DOI) (Rogers, 2003) and the technology, organizational and environmental (TOE) framework (Tornatzky and Fleischer, 1990). Later are also suggested items in order to test the constructs of the proposed model. The paper proceeds as follows: First of all we define *Cloud Computing* and we refer some literature review (section 2). Based on it, it is presented a research model to analyse *Cloud Computing* adoption (section 3). Finally we show the discussion and present the conclusions.

2 THEORETICAL BACKGROUND

2.1 *Cloud Computing* concept

In fact, no common standard or definition for *Cloud Computing* seems to exist (Foster et al., 2008, Gong et al., 2010, Zhang et al., 2010, Marston et al., 2011, Sultan, 2010). In Vouk's (2008) opinion, *Cloud Computing* is a recent term, based on decades of research in virtualization, distributed computing, utility computing, and more recently networking, web and software services. The origin of the term "Cloud" appears somewhat controversial. Sultan (2010) supports the theory that this term comes from the literature in IT that illustrates the Internet and remote environment like a cloud, to hide its complexity. However, Wu, Lan et al. (2011) considered the term is derived from the idea of business and users being able to access applications from everywhere in the world. The aim of *Cloud Computing* is defined by Goscinski and Brock (2010) as "a huge computational power and storage capacity to solve problems such as analysing investment decisions and risk in financial portfolios, delivering personalized medical information, and powering computer games". Following the same idea, Slabeva and Wozniak (2010) refer that *Cloud Computing* essentially represents "the increasing trend towards the external deployment of IT resources, such as computational power, storage or business applications, and obtaining them as services". According to Marston, Li et al. (2011) *Cloud Computing* can deliver all the functionality of existing IT services as it decreases the initial costs of computing. If we intend to understand what *Cloud Computing* is, we should know the three different types of services offered by the cloud: **1.**Infrastructure as a service (IaaS), where vendors offer computing power and storage space (eg. Rackspace, Amazon Elastic Compute Cloud and GoGrid). **2.** Platform as Service (PaaS), which provides a platform in the cloud, upon which applications can be developed and executed (eg. Salesforce.com, Google AppEngine and Microsoft Azure). **3.** Software as a service (SaaS), which allows users access to applications using the internet, instead of installing them on their own computer (eg. Gmail, Joyent and SalesForce CRM).
In a brief way, from these contributions, *Cloud Computing* can be defined as a model where process, storage or software are in network where users can reach all services using the internet. The user does not have to care about technical support (storage, maintenance, upgrade, backup), as this task belongs to the vendor. Many are the characteristics that qualify the *Cloud Computing* model: it provides a better profitability of investments in hardware and software; it is based on a pay-per-use model; it

values the resource optimization and allows for focus and centralization in business. On the other hand, aspects as security and privacy are the key negative facets of Cloud Computing.

2.2 Adoption models

The most used theories about technology adoption at the firm level are the DOI model and the TOE framework (Oliveira and Martins, 2011, Leinbach, 2008, Lin and Lin, 2008, Ramdani and Kawalek, 2009): some authors analysed the adoption of technology based on the TOE framework, others have chosen to study it through the DOI model, although others have suggested studying the adoption of technology based on the two models together.
As far as *Cloud Computing* is concerned, several studies on its technical characteristics have been developed (Iyer and Henderson, 2010, Sultan, 2010, Khajeh-Hosseini et al., 2011). Yet on the adoption of *Cloud Computing*, references available are scarce. The exception studies are: Behrend, Wiebe et al.(2011) analyses the adoption of *Cloud Computing* in community colleges on an individual level; and the adoption of *Cloud Computing* in the high tech industry in Taiwan, based on the TOE framework (Low et al., 2011). From this gap in the literature, it is important to understand the factors affecting the adoption of *Cloud Computing*, based on two other models, which have already been developed and strongly supported, DOI and TOE (Table 1).

Theory	Technology	Source	Constructs										
			RA	C	CX	TR	IS	FS	CS	TMS	SC	CP	RS
DOI	E-Commerce	(Ling, 2001)	X	X	X			X		X		X	X
	Internet/E-Business	(Ifinedo, 2011b)	X	X	X					X		X	X
TOE	Cloud Computing	(Low et al., 2011)	X	X	X	X		X		X		X	
	E-Business	(Lin and Lin, 2008); (Oliveira and Martins, 2010); (Zhu and Kraemer, 2005); (Zhu et al., 2006b)		X		X	X	X				X	X
	E-Commerce	(Ghobakhloo et al., 2011)	X	X				X	X	X		X	
	Internet	(Zhu et al., 2004)				X	X	X				X	X
	Knowledge management and enterprise systems	(Ramdani and Kawalek, 2009)	X	X	X		X	X		X		X	
	Open Systems	(Chau and Tam, 1997)			X								
	RFID	(Thiesse et al., 2011)		X	X			X	X	X		X	
	Web Services	(Lippert and Govindarajulu, 2006)					X	X			X	X	X
DOI & TOE	Benchmarking	(Azadegan and Teich, 2010)	X	X									
	Collaborative commerce	(Chong et al., 2009)	X	X	X					X		X	
	E-Commerce	(Leinbach, 2008)	X	X		X	X	X	X		X	X	X
	Open Source	(Dedrick and West, 2003)	X	X					X				
	Digital transformation	(Zhu et al., 2006a)	X	X	X	X		X	X		X	X	
DOI & TOE & Others	Internet	(Alam, 2009)				X			X	X			
	Green IT initiatives	(Bose and Luo, 2011)						X					X

Note: Relative Advantage (RA); Compatibility (C);Complexity(CX);Technology Readiness (TR); International Scope (IS); Firm Size (FS); Cost Savings (CS);Top Management Support (TMS); Security Concerns (SC); Competitive Pressure (CP); and Regulatory Support (RS).

Table 1. Constructs used on DOI model and TOE framework.

2.2.1 Diffusion of innovation (DOI)

DOI is a theory of how, why, and at what rate new ideas and technology spread through cultures (Rogers, 2003) and many authors suggested the study of the DOI (Alam, 2009, Azadegan and Teich, 2010, Dedrick and West, 2003, Ifinedo, 2011a, Leinbach, 2008, Zhu et al., 2006a). It suggests that DOI is predominantly based on characteristics of the technology and on users' perceptions of the system. DOI theory sees innovations as being communicated through certain channels over time and within a particular social system (Rogers, 2003). Rogers (2003) analyses the diffusion of innovation and suggests the following characteristics that influence the adoption of innovation: relative advantage, compatibility, complexity, observability, and trialability. Relative advantage is the degree to which an innovation can bring benefits to an organization. Compatibility refers to the degree to which an innovation is consistent with existing business processes, practices and value systems. Complexity considers the degree to which an innovation is difficult to use. Observability is the degree

to which the results of an innovation are visible to others. And last, we have trialability, which refers to the degree to which an innovation may be experimented (Zhu et al., 2006a, Rogers, 2003). DOI is an important theory that leads us to various information systems innovations (Zhu et al., 2006a). However, the DOI theory leads specially with the context of innovation and it tends to ignore other factors that can influence the firm's decision (Alam, 2009, Lippert and Govindarajulu, 2006) to implement *Cloud Computing* as environmental factors: external pressure and regulatory support.

2.2.2 Technology, organization and environment (TOE) framework

According to Tornatzhy and Fleisher (1990), the process by which a firm adopts and implements technological innovations is influenced by the technological context, the organizational context, and the environmental context (Tornatzky and Fleischer, 1990). Several studies have based on TOE framework to analyse IT adoption by firms (Low et al., 2011, Oliveira and Martins, 2010, Ifinedo, 2011b, Zhu and Kraemer, 2005, Thiesse et al., 2011, Ramdani and Kawalek, 2009, Wang et al., 2007, Ghobakhloo et al., 2011, Chau and Tam, 1997). The technology context refers to characteristics of the technologies which are available for possible adoption by the organization, and the current state of technology in the organization. The organizational context consists of the organizational structure, the presence of innovation – enabling processes such as informal communication and strategic behaviour of top management, and the size and slack resources of the organization. The environmental context mixes nearby market elements such as competitive pressure and regulatory support. This framework is consistent with the DOI model of Rogers (Zhu et al., 2004, Oliveira and Martins, 2011, Ifinedo, 2011b). The TOE framework includes the organizational and technologies context as a main aspect to analyse technology adoption as the DOI incorporates. However, the TOE framework also includes a new and important component, the environment context (Oliveira and Martins, 2011).

3 RESEARCH MODEL

In this study, it is proposed that several factors influence different levels of *Cloud Computing* adoption at firm level. Our research model combines the DOI model and the TOE framework, once they complement each other, which seems to be a better solution to this analysis, since it combines different contexts, as mentioned previously. The research model (Figure 1) includes the context of innovation defined in the DOI theory and the three contexts presented on the TOE framework. DOI and TOE are used extensively in IT adoption studies, and have enjoyed consistent empirical support. In accordance with the literature review, eleven propositions are developed as we see in Figure 1.

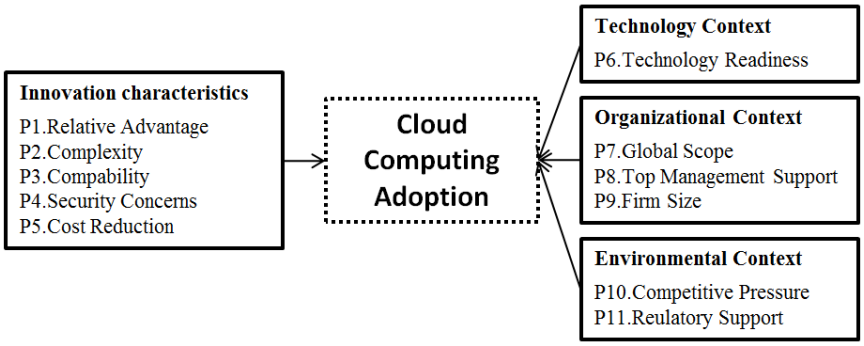

Figure 1. The Research model

3.1 Innovations characteristics

Considering the adoption of *Cloud Computing*, we suggest five variables in the context of the characteristics of innovation: relative advantage, complexity, compatibility, security concerns and cost reduction.

3.1.2 Relative advantage

Relative advantage is defined by Rogers as "the degree to which an innovation is perceived as being better than the idea it supersedes." (Low et al., 2011, Ifinedo, 2011b). Innovations that have a clear, unambiguous advantage in either effectiveness or cost-effectiveness are more easily adopted and implemented (Greenhalgh et al., 2004). Relative advantage of *Cloud Computing* can be defined as the potential to help increase sales and reduce costs (Zhu et al., 2006a). For this analysis, the following proposition will be considered: **P1.Relative advantage will positively influence *Cloud Computing* adoption.**

3.1.2 Complexity

Rogers describes complexity as "the degree to which an innovation is perceived to be relatively difficult to understand and use" (Rogers, 2003). The easier it is the understanding, implementation and innovation, more easily it will be adopted. For this analysis, the following proposition will be considered: **P2.Complexity will negatively influence *Cloud Computing* adoption.**

3.1.3 Compatibility

Rogers describes compatibility as "the degree to which innovation fits with the potential adopter's existing values, previous practices current needs". In the literature review, compatibility has been considered an essential factor for innovation adoption (Thiesse et al., 2011, Dedrick and West, 2003, Ling, 2001, Azadegan and Teich, 2010). If the technology is incompatible, there is a need to make some adjustments in processes that must be learned. For ill be considered: **P3. The high compatibility will positively influence *Cloud Computing* adoption.**

3.1.4 Security concern

Like everything else involving computers, security is a critical issue in Cloud Computing (Schneiderman, 2011). With the convergence of storage and computing in a shared multi-user environment, cloud computing heightens concerns of security (Schneiderman, 2011; Shen & Tong, 2010). Moving to the cloud adds new layers of complexity for securing data and will thus influence the firms' decision to adopt the innovation. For this analysis, the following proposition will be considered: **P4. Security concerns will positive influence *Cloud Computing* adoption.**

3.1.5 Cost reduction

One of the significant advantages of *Cloud Computing* is cost savings (Cervone, 2010): reducing the cost of IT services while increasing processing income, reliability, availability and flexibility and decreasing processing time (Zhu et al., 2006a). For this analysis, the following proposition will be considered: **P5. Cost savings will positive influence *Cloud Computing* adoption**

3.2 Technology context

Technology context refers to the technological characteristics available in the organization for the adoption of technology.

3.2.1 Technology readiness

Technology readiness encloses infrastructure and IT human resources. On the one hand, we have the technological infrastructure that refers to installed network technologies and enterprise systems, which provide a platform on which the *Cloud Computing* applications can be built. On the other hand, there are the IT human resources which provide the knowledge and skills to implement *Cloud Computing* related IT applications (Wang et al., 2007). Therefore, firms with a higher degree of technology readiness are more prepared for the adoption of *Cloud Computing*. For this analysis, the following proposition will be considered: **P6.Technology Readiness will positively influence *Cloud Computing* adoption.**

3.3 Organizational context

The organizational context is defined in terms of resources available to support the adoption of the innovation (Lippert and Govindarajulu, 2006).

3.3.1 Globe scope

Global scope refers to the extent of business expansion into the international market (Zhu et al., 2004). The global reach of the Internet makes it potentially more beneficial as well (Zhu and Kraemer, 2005). *Cloud Computing* facilitates the connection between jobs in the different places. For this analysis, the following proposition will be considered: **P7. Global scope is positively associated with *Cloud Computing* adoption.**

3.3.2 Top management support

It is very important in any firm to have a good environment and satisfactory resources in order to adopt new technologies. Top management plays an important role because *Cloud Computing* implementation may involve integration of resources and reengineering of processes (Low et al., 2011). When top managers understand the importance *Cloud Computing* can have for their business, they will influence other organizational members to accept it. On the other hand, when they do not understand the advantages, they will be considered as a barrier to the *Cloud Computing* adoption. For this analysis, the following proposition will be considered: **P8. Top management support will positively influence *Cloud Computing* adoption.**

3.3.3 Firm size

One of the factors studied in the scientific approach which is considered as determinant is firm size. It is common that huge firms have more advantages than smaller ones, as they have more resources, with more developed technology and they can take greater risks associated with innovation adoptions. In this sense, firm size is a crucial feature which contributes to the adoption of *Cloud Computing* in innovative technological development (Low et al., 2011). For this analysis, the following proposition will be considered: P**9. Firm size will positively influence *Cloud Computing* adoption.**

3.4 Environmental context

In the end, environmental context includes the firm's competitors and the regulatory environment (Tornatzky and Fleischer, 1990).

3.4.1 Competitive pressure

Competitive pressure has long been recognized in the innovation diffusion literature as an important driver for technology diffusion. It refers to the level of pressure felt by the firm from competitors within the industry (Oliveira and Martins, 2010, Low et al., 2011). By adopting *Cloud Computing*, firms benefit greatly from better understanding of market visibility, greater operation efficiency, and more accurate data collection (Misra and Mondal, 2011). For this analysis, the following proposition will be considered: **P10. Competitive pressure will be positively influence *Cloud Computing* adoption.**

3.4.2 Regulatory support

Regulatory support is another critical environmental factor that can influence *Cloud Computing* adoption. It refers to the support given by the authority in order to persuade the increase of IS innovations in firms. The perception that firms have on the existing laws and regulations can be determinant in this process. Thus, governments could encourage the adoption of *Cloud Computing* by creating rules to protect businesses in the use of this system. National legislation, as well as European Union regulations, requires, now, some restrictions regarding the handling and protection of data. However, it is still far short from firms' expectations. For this analysis, the following proposition will be considered: **P11. Regulatory support will positively influence *Cloud Computing* adoption.**

3.5 *Cloud Computing* adoption

Measuring the adoption of cloud computing is done by creating an index using the company's services, infrastructure and platforms available in the cloud. An item is also proposed to measure the intention to use cloud computing by the company. Table 2 presents the measure items based on the literature for the proposed constructs.

Items	Adapted source:
Relative Advantage: 1*.Cloud Computing* allows you to manage business operations in an efficient way. **2.**The use of *Cloud Computing* services improves the quality of operations. **3.**Using *Cloud Computing* allows you to perform specific tasks more quickly. **4.** The use of *Cloud Computing* offers new opportunities. **5.**Using *Cloud Computing* allows you to increase business productivity.	(Ifinedo, 2011b, Ghobakhloo et al., 2011, Thiesse et al., 2011)
Complexity: **1.**The use of *Cloud Computing* requires a lot of mental effort. **2.**The use of *Cloud Computing* is frustrating. / is easy. **3.** The use of *Cloud Computing* is too complex for business operations. **4.**The skills needed to adopt *Cloud Computing* are too complex for employees of the firm.	(Ifinedo, 2011b, Moore and Benbasat, 1991, Thiesse et al., 2011)
Compatibility: **1.**The use of *Cloud Computing* fits the work style of the company. **2.**The use of *Cloud Computing* is fully compatible with current business operations **3.**Using *Cloud Computing* is compatible with your company's corporate culture and value system. **4.**The use of *Cloud Computing* will be compatible with existing hardware and software in the company.	(Ifinedo, 2011b, Zhu et al., 2006a, Thiesse et al., 2011)
Technology Readiness: **1.**The percentage of employees who have Internet access. **2.** The number of computers per employee. **3.** The company knows how IT can be used to support operations. **4.** There are within the company the necessary skills to implement *Cloud Computing*.	(Zhu and Kraemer, 2005, Misra and Mondal, 2011, Oliveira and Martins, 2010, Ifinedo, 2011a)
Security Concerns: **1.**Concern about data security on the Internet. **2.** Concern about privacy on the Internet. **3.** Using the *Cloud Computing* solutions is trustworthy.	(Zhu et al., 2006a, Luo et al., 2010, Wu, 2011)
Global Scope: **1.**Does the company have offices outside the country? **2.** Are the company's headquarters located outside the country?	(Zhu and Kraemer, 2005, Misra and Mondal, 2011)
Top Management Support: **1.**The company's management supports the implementation of *Cloud Computing*. **2 .**The company's top management provides strong leadership and engages in the process when it comes to information systems company. **3.** The company management is willing to take risks (financial and organizational) involved in the adoption of *Cloud Computing*.	(Chwelos et al., 2001, Alam et al., 2011, Zhu et al., 2010)
Firm Size: **1.**The number of company employees. **2.** Annual business volume.	(Premkumar and Roberts, 1999 ,Zhu et al., 2006a)
Cost Reduction: **1.**The reducing costs of adoption of *Cloud Computing* are smaller than the implementation costs. **2.** Reduction of energy costs and environmental costs. **3.** Maintenance costs of *Cloud Computing* are very low.	(Rajan and Jairath, 2011, Sangle, 2011, Ghobakhloo et al., 2011)
Competitive Pressure: **1.**Firms think that *Cloud Computing* has an influence on competition in their industry. **2.** Our firm is under pressure from competitors to adopt *Cloud Computing*. **3.** Some of our competitors have already started using *Cloud Computing*.	(Oliveira and Martins, 2010, Ifinedo, 2011a)
Regulatory Support: **1.**There is legal protection in the use of *Cloud Computing.* **2.** The data protection policies are regulated. **3.** The laws and regulations that exist nowadays are sufficient to protect the use of *Cloud Computing*.	(Zhu and Kraemer, 2005, Alam et al., 2011)
Cloud Computing Adoption: **1.**Cloud computing services used by firm. **2.** The company uses a *Cloud Computing* platform. **3.** The company uses a *Cloud Computing* infrastructure. **4.** What is firm relationship with *Cloud Computing*? (Using for remotely hosted apps to store data or both; Currently investigating; Investigated but rejected; Not considered at all)	(Wu, 2011, Ifinedo, 2011a)

Table 2. Measure Items

4 DISCUSS

4.1 Theoretical and managerial implications

This study has significant implications for research on *Cloud Computing*: **1.** From the knowledge that we could get, there has been no previous study to analyze the factors influencing the adoption of cloud computing by firms. This study incorporates four distinct dimensions (innovation characteristics, organizational, technological and environmental context) which are essential to the adoption of *Cloud Computing*. **2.** This study should be the starting point for future developments on the determinants that facilitate or inhibit the adoption of *Cloud Computing* by firms. **3.** This study can serve as a basis for the decision makers of firms considering whether to adopt cloud computing in their firms, comparing their experience with the aims of this study to make an informed decision before engaging in cloud-based initiatives.

4.2 Methodological implications and validation approaches

To test the propositions suggested here, it should be developed a survey instrument based on the measure items proposed. It is also suggested the use of a pilot study in several companies in order to improve the variables presented. The theoretical approach developed in this study should be implemented and tested for a range of companies and countries in order to test the model suggested.

Thus, companies could use the findings or results produced. In addition to applying the model must also be conducted empirical tests to validate the connection between the constructs.

4.3 Limitations and future research

This study is in its early theoretical concept, in which a preliminary model is suggested, based on the literature review and conceptual reasoning. The next step is the application and validation of the model to a set of firms and countries, in order to test the developed framework and directly assess its explanatory and predictive power. Future studies may examine other relationships that were not foreseen in this model and which will enhance the ability to explain the dependent variable. Thus, this study opens up others possibilities for future investigations. The refinement of the constructs and measures proposed are one of the possibilities. Another possibility is the investigation of more complex relationships between the independents and the dependent variables of the model.

5 CONCLUDING REMARKS

Cloud Computing is the natural evolution of information systems technologies. It is currently exploited by technology due to its properties: speed, scalability and cost efficiency. It is a business-oriented model, it is based on the pay-per-use model and it allows the storage, management, sharing and availability of data, software, applications and/or computational services over the internet.
This study was intended to understand the process of technology adoption and to identify factors that affect the adoption of *Cloud Computing*. The model was designed based on the DOI and the TOE theory framework. The theoretical research carried out resulted in a set of contexts that may influence the adoption of *Cloud Computing*: characteristics innovations, technology, organizational and environmental context. The study is a unique contribution in defining the model of research and development in the dimensions that constitute it, and it is a resource for firms and researchers that may use the conclusions of this study, expanding their knowledge in this area and eventually develop other externalities. We also expect this study to provide a theoretical framework that is grounded and a starting point for future research on the adoption of *Cloud Computing*.

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